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Charleston

November 20, 1998

Mr. Al Urrutia
437 CES/CEVR
100 W. Stewart Avenue
Charleston AFB, South Carolina 29404-4827

Subject: Extended Bioventing Testing Results for Site SS-41, Former Building 93 Site
(Former Fuel Pumping Station No. 3), Charleston AFB, South Carolina
(Contract No. F41624-92-8036, Order 17)

Dear Mr. Urrutia:

This letter presents the results of the bioventing system monitoring performed by Parsons Engineering Science, Inc. (Parsons ES) during June 1998 at Site SS-41, Former Building 93 (former Fuel Pumping Station No. 3), Charleston Air Force Base (AFB), South Carolina. Soil gas sampling for field and laboratory analyses was performed on 22 June 1998, approximately 1 month following blower shut down. *In situ* respiration testing was performed from 22 through 26 June 1998 to assess the extent of remediation achieved during approximately 2.5 years of pilot-scale system operation followed by 1 year of expanded-scale air injection bioventing. Also, five groundwater samples were collected and submitted for laboratory analysis as requested by the South Carolina Department of Health and Environmental Control (SCDHEC) during their review of the Corrective Action Plan (CAP) prepared for the site (Parsons ES, 1997a). The purposes of this letter are to summarize site and bioventing activities to date, present the results of the June 1998 system monitoring event, compare these results with previous pilot testing and monitoring results, and to recommend future activities for the site based on these findings. A copy of this letter has also been forwarded to Major Edward Marchand with the Air Force Center for Environmental Excellence Technology Transfer Division (AFCEE/ERT).

SITE REMEDIATION HISTORY

Site Description

Site SS-41 consists of the entire fuel hydrant system (exclusive of the Petroleum, Oils, and Lubricant (POL) Bulk Fuel Storage Depot [POL Fuel Depot]) (Parsons ES, 1996). Existing or former fuel pumping stations in the fuel hydrant system include those located at Building 99 (Fuel Pumping Station No. 1), Building 95 (Fuel Pumping Station No. 2), and former Building 93 (former Fuel Pumping Station No. 3). Former Building 93, which is the area of concern for this project, is located in the east-central part of Charleston AFB. Former Building 93 is the only area at Site SS-41 that failed two risk-based screening tiers using the South Carolina Risk-Based Corrective Action (RBCA)



AQ M01-03-0528

guidelines for petroleum release sites (SCDHEC, 1995). Therefore, former Building 93 was the only area of the Site SS-41 fuel hydrant system that was proposed for bioventing remediation under the CAP (Parsons ES, 1997a). This area of concern will be referred to as the former Building 93 site throughout this letter.

Former Fuel Pumping Station No. 3 (former Building 93) and six associated 50,000-gallon underground storage tanks (USTs) were removed and demolished from July through October 1993 as part of a Navy Military Construction (MILCON) hydrant/apron renovation project. The locations of the former building and USTs are shown on Figure 1. An unknown quantity of fuel-contaminated soil was excavated and transported off-site during UST removal activities. The UST excavation was backfilled with clean soil and the upper three feet of the former tank pit was backfilled with construction-generated soil to bring the site to final grade. The 8-inch primary fuel line from the POL Fuel Depot remained intact and is still in operation.

Bioventing Pilot Testing

After the Building 93 Fuel Pumping Station was demolished, a one-year bioventing treatability pilot study was initiated at the site by Parsons ES (formerly Engineering-Science, Inc. [ES]) under contract to AFCEE/ERT (ES, 1994). A limited soil gas survey was performed to identify areas with fuel-contaminated, oxygen-depleted soils suitable for the bioventing study. Two 4-inch diameter vertical vent wells (VWs), a regenerative blower, an electrical power supply, and four multi-depth vapor monitoring points (MPA, MPB, MPC, and MPD) were installed at the site to conduct the test (Figure 1). This system was operated and monitored by Parsons ES as a pilot study for 1 year, from July 1994 through August 1995. The initial air permeability and respiration tests associated with the study were completed in November 1993 (ES, 1994). Following the one-year pilot study, the Base operated the pilot test blower system for an additional 18 months (from September 1995 through February 1997).

Expanded-Scale Bioventing System Installation

Based on positive results from the 1-year bioventing pilot test (AFCEE, 1996), funding was provided by AFCEE to design and install an expanded system for continued bioventing treatment of vadose zone soils at the former Building 93 site. Funding was also provided by AFCEE for one year of expanded system monitoring, with soil gas sampling and respiration testing at the end of the 1-year operation period. An expanded bioventing system consisting of ten new 2-inch diameter VWs; ten new MPs, two new blower systems, and associated piping, controls, and electrical service was installed at the site. The four existing MPs installed during previous pilot testing efforts (MPA, MPB, MPC, and MPD) continue to be used to monitor system performance. One of the original pilot test vent wells (VW-1) was retrofitted for soil gas monitoring, and the other pilot test vent well (VW-2) was incorporated into the full-scale system for air injection. The regenerative blower system that had been used for pilot-scale testing was shut down, dismantled and removed from the site.

The new system was installed by Parsons ES and subcontractors between February 25 and May 8, 1997, in accordance with the design described in the *Final Corrective Action Plan for Expanded Bioventing System, Site SS-41, Former Building 93 (Fuel Pumping Station No. 3), Charleston AFB, South Carolina* (Parsons ES, 1997a). The only deviations from the work plan were the installation of one additional vent well (VW-12), installation of one additional monitoring point (MPN), and relocation of one monitoring point (MPK) on the north end of the site. Also, several of the MPs were constructed with only a single screen due to shallow water table conditions on the north end of the site. Figure 1 shows the site layout with the locations of the bioventing system components. Additional record drawings showing the final design details of the system components are provided in the operation and maintenance manual (Parsons ES, 1997b). A summary of field activities, initial sampling results, and initial monitoring results from the 1997 event are provided in a letter to Major Ed Marchand at AFCEE/ERT, dated 28 October 1997 (Parsons ES, 1997c).

1998 BIOVENTING SYSTEM MONITORING EVENT

Soil gas sampling and *in situ* respiration testing were performed in June 1998 after the 1-year expanded system operation period. The system was shut down 1 month prior to soil gas sampling to allow soils and soil gas to come to equilibrium in order to compare initial and current conditions. The blower system was re-started and optimized following testing to continue bioventing treatment of site soils. Results of the June 1998 soil gas sampling and respiration testing at the former Building 93 site are presented in this report, and compared with previous results.

Soil Gas Chemistry Results

Field screening and collection of soil gas samples for laboratory analysis were performed on 22 June 1998 following approximately 2.5 years of pilot-scale system operation, 1 year of expanded-scale system operation, and 1 month of system shutdown. Soil gas samples were collected from each MP interval, and field-screened to assess soil gas concentrations of oxygen, carbon dioxide, and total volatile hydrocarbons (TVH). In addition, soil gas samples for laboratory analysis were collected from eight MP screened intervals that exhibited the greatest contamination during field screening (MPD-8, MPF-7.8, MPG-7.75, MPH-6.75, MPI-5.5, MPJ-5, MPK-5.3, and MPM-3.2). For all soil gas sampling events discussed in this report, laboratory samples were sent to Air Toxics, Ltd. in Folsom, California and analyzed for total volatile hydrocarbons (TVH) and benzene, toluene, ethylbenzene, and xylenes (BTEX) using US Environmental Protection Agency (USEPA) Method TO-3. Field and laboratory soil gas sampling results from November 1993, August 1995, June 1996, April 1997, and June 1998 are presented in Table 1 (attached).

Static oxygen concentrations in soil gas have generally increased at most sampling locations with continued air injection bioventing at the site (Table 1). The overall increases in static soil gas oxygen concentrations suggest that aerobic hydrocarbon biodegradation rates have decreased substantially, suggesting that less substrate (fuel hydrocarbon contamination) remains in the soil at most locations.

Field soil gas TVH concentrations have generally decreased at all the MPs with the exceptions of MPI-5.5, MPJ-5, and MPM-3.2. Laboratory soil gas TVH and BTEX concentrations have decreased similarly. A comparison of field and laboratory TVH results suggests that concentrations of methane may be present at MPI-5.5 and MPM-3.2. It is possible that some anaerobic zones of soil exist near these MPs, and that methanogenesis is occurring in these areas. At approximately two thirds of the soil gas sampling locations, TVH concentrations have been reduced to below 1,000 ppmv. The greatest contaminant reductions in the initial pilot study area (MPA, MPB, MPC, and MPD) were observed at MPD-8, where TVH and total BTEX were reduced by 98.9 and 96.0 percent, respectively, over a 3.5-year treatment period (2.5 years of pilot testing plus 1 year of expanded-scale treatment). The greatest reductions within the expanded-scale area were observed at MPF-7.8, where laboratory TVH was reduced by 97.8 percent and total BTEX was reduced by 95.9 percent over a 1-year treatment period. These data indicate that although TVH levels at the former Building 93 site remain high in some locations, both TVH and the risk-driving BTEX compounds are being biodegraded by the bioventing system operation.

Respiration Test Results

Respiration tests can be used as a qualitative guide to determine the degree of soil remediation that has been achieved due to aerobic biodegradation. Field respiration testing has been conducted four times during bioventing implementation at the former Building 93 site. The first three test events were associated with the initial bioventing pilot study and were conducted in November 1993 (prior to system startup), and in January 1995 and August 1995 (after 6 months and 1 year of pilot-scale system operation, respectively).

The fourth *in situ* respiration testing event was performed from 22 through 26 June 1998, after the expanded-scale bioventing system had been shut down for thirty days. Point respiration tests were conducted at MPA-8, MPD-8, MPF-7.8, MPI-5.5, MPK-5.3, and MPM-3.2. The tests were performed according to protocol procedures (Hinchee *et al.*, 1992). The June 1998 point respiration tests were performed by injecting air (oxygen) into each MP screened interval for a 19-hour period using a 1-cubic-foot-per-minute (cfm) pump. After the pump was turned off, changes in soil gas chemistry at each MP was measured for at least 3 days. Observed rates of oxygen utilization were used to estimate aerobic fuel biodegradation rates for each respiration test. Respiration and fuel biodegradation rates for site soils are shown on Table 2.

Throughout the initial 1-year pilot test and prior to expanded-scale system installation, respiration rates at MPD-8 were relatively constant. As can be seen from Table 2, a significant reduction occurred in the respiration and fuel biodegradation rate at MPD-8 following 1 year of expanded-scale system operation, suggesting that fuel hydrocarbon concentrations have been significantly reduced at this location. During the June 1998 respiration test, fuel biodegradation rates ranged from 150 mg/kg/year at MPD-8, to 1,400 mg/kg/year at MPI-5.5 (Table 2). These results suggest that sufficient concentrations of fuel hydrocarbons remain in the unsaturated soils to sustain moderate respiration rates.

Groundwater Sampling Results

During the June 1998 sampling event, Parsons ES collected groundwater samples from four existing groundwater monitoring wells (MW-10, MW-11, MW-12, and MW-14) and one vent well (VW12), and submitted them to Specialized Assays, Inc. for laboratory analysis of volatile organic compounds (VOCs) by USEPA Method SW8260B and semivolatile organic compounds (SVOCs) by USEPA Method SW8270C. As can be seen in Table 3, no VOC or SVOC compounds were detected above their method detection limits. There were no contaminants detected in either the trip blank or the laboratory blank.

CONCLUSIONS RECOMMENDATIONS

Based on these findings, residual BTEX and TPH compounds in site soils have been reduced as the result of bioventing remediation. However, aerobic hydrocarbon biodegradation rates are still significant at several locations, indicating that continued bioventing system operation would be beneficial. Since soil gas TVH levels are still high in several locations, and the soils are still oxygen deficient (<5 percent) throughout most of the site (under static conditions), it is recommended that the expanded-scale bioventing system remain in operation to continue to treat soils at the former Building 93 site.

Based on the results from extended testing of the bioventing system and groundwater monitoring, the following recommendations are made:

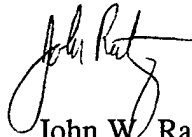
- Continue to operate the existing bioventing system until a no-further-remedial-action-planned (NFRAP) agreement is reached with the SCDHEC. Sustained bioventing system operation will continue to oxygenate soils and enhance aerobic biodegradation of any petroleum hydrocarbon contaminants, which may leach from the contaminant zone. In addition, continued bioventing system operation will promote oxygen delivery to the saturated zone through diffusion.
- Annual respiration testing and soil gas sampling is recommended until respiration rates and TVH and BTEX concentrations in soil gas reach asymptotic levels. When asymptotic levels have been reached, confirmatory soil sampling is recommended to document contaminant reduction and obtain regulatory closure.
- Continued institutional control over the area. Workers performing any excavation in the contaminated area must wear protective clothing and gloves and be equipped with respirators if ambient levels of total volatiles exceed 5 ppmv.
- Parsons ES does not recommend continued groundwater monitoring since contaminants were not detected in the June 1998 sampling effort.

In December 1998 or January 1999, Parsons ES will be on the Base to conduct soil sampling activities at IRP Site FT-03. During this site visit, Parsons ES will check the blowers at former Building 93 to ensure that they are still operating properly.

This letter report is the last deliverable for the former Building 93 site under the AFCEE Extended Bioventing Project. Parsons ES looks forward to continuing to work with the Air Force in obtaining closure at the Building 93 site at Site SS-41, and if you have any questions or require additional information concerning this report, please contact the Parsons ES site manager, Mr. Dave Teets at (406) 254-6533, or me at (303) 831-8100.

Sincerely,

PARSONS ENGINEERING SCIENCE, INC.



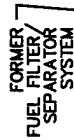
John W. Ratz, P.E.
Project Manager

Attachments: Figure 1, Tables 1 through 4

cc: Major Ed Marchand (AFCEE/ERT)
Mr. Dave Teets (Parsons ES-Billings)
Mr. Steve Ratzlaff (Parsons ES-Atlanta)
File 727876.28210.E Letter Results Report

REFERENCES

- Air Force Center for Environmental Excellence (AFCEE). 1996. Completion of One-Year Bioventing Test, Site SS-41, Former Fuel Pumping Station, Building 93. Letter results report memo to Charleston AFB 437 SPTG/CEVR from HQ AFCEE/ERT. 3 April.
- Engineering-Science, Inc. 1994. *Part I, Bioventing Pilot Test Work Plan and Part II, Draft Interim Bioventing Pilot Test Results Report for IRP Site SS-41, Former Flightline Fuel Pump House, Charleston AFB, South Carolina.* January.
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- Parsons ES. 1997a. *Final Corrective Action Plan for Expanded-Scale Bioventing System, Site SS-41, Charleston AFB, South Carolina.* April.
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- Parsons ES. 1997c. Letter report summarizing initial results for the expanded-scale bioventing system installed at Site SS-41, Charleston AFB, South Carolina. October 28.
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APPROXIMATE EXTENT OF SOIL
TREATMENT AREA WITH SOIL GAS
OXYGEN CONCENTRATIONS EXCEEDING
7 PERCENT (BASED ON MAY/JUNE
1997 SOIL GAS SAMPLING RESULTS).

FORMER
RECLAIMABLE
GUEL LIST

LEGEND

MW-14

WV3 Δ VENT WELL

MPA ● SOIL VAPOR MONITORING POINT

--- AIR INJECTION HEADER PIPE (BURIED)
(13.8/20.8) SOIL GAS OXYGEN CONCENTRATION (%)
(SHALLOW/DEEP SCREENS)

FORMER UST
LOCATIONS

Flightline Ditch

To Taxiway #4

Effect
45

FIGURE 1

SITE PLAN AND BIOVENTING SYSTEM LAYOUT

Expanded Bioventing System
Former Building 93, Site SS-41
Charleston AFB, South Carolina

**PARSONS
ENGINEERING SCIENCE, INC.**

Denver, Colorado

TABLE 1
SOIL GAS FIELD AND LABORATORY ANALYTICAL RESULTS
FORMER BUILDING 93, SITE SS-41
CHARLESTON AFB, SOUTH CAROLINA

Sample Location	Sample Depth (ft bgs) ^{b/}	Sampling Date	Field Screening Data			Laboratory Analytical Data ^{d/}				
			Oxygen (percent)	Carbon Dioxide (percent)	TVH (ppmv) ^{d/}	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
MPA	5	11/17/93	NM ^{d/}	NM	NM	--- ^{e/}	---	---	---	---
		8/7/95	0.5	8.1	58	---	---	---	---	---
		6/11/96	0.0	12.5	200	---	---	---	---	---
		4/24/97	0.0	10.0	2,200	---	---	---	---	---
		6/22/98	7.2	8.7	225** ^{f/}	---	---	---	---	---
MPA	8	11/17/93	0.1	9.2	>20,000 ^{g/}	---	---	---	---	---
		8/7/95	0.0	6.3	360	---	---	---	---	---
		6/11/96	0.0	12.0	480	---	---	---	---	---
		4/24/97	0.0	9.8	2,800	---	---	---	---	---
		6/22/98	1.6	8.6	900**	---	---	---	---	---
MPB	5	11/17/93	0.0	7.9	4,800	---	---	---	---	---
		8/7/95	0.0	8.4	220	---	---	---	---	---
		6/11/96	0.5	14.5	200	---	---	---	---	---
		4/24/97	0.8	9.5	1,560	---	---	---	---	---
		6/22/98	1.9	12.0	20	---	---	---	---	---
MPB	8	11/17/93	0.3	7.7	>20,000	---	---	---	---	---
		8/7/95	1.0	7.1	640	---	---	---	---	---
		6/11/96	0.5	14.5	400	---	---	---	---	---
		4/24/97	0.0	10.0	3,200	---	---	---	---	---
		6/22/98	2.0	11.1	200	---	---	---	---	---
MPC	5	11/17/93	NM	NM	NM	---	---	---	---	---
		8/7/95	0.0	7.6	98	---	---	---	---	---
		6/11/96	0.2	12.0	160	---	---	---	---	---
		4/24/97	0.0	10.0	1,800	---	---	---	---	---
		6/22/98	4.9	10.5	44	---	---	---	---	---
MPC	8	11/17/93	0.0	8.0	>20,000	21,000	0.75U ^{h/}	0.75U	5.4	12
		8/8/95	0.0	6.9	260	700	0.50	0.014U	0.014U	2.0
		6/11/96	0.0	12.0	190	---	---	---	---	---
		4/24/97	0.0	10.1	1,400	---	---	---	---	---
		6/22/98	4.0	8.8	40	---	---	---	---	---
MPD	5	11/17/93	NM	NM	NM	---	---	---	---	---
		8/7/95	0.0	12.1	540	---	---	---	---	---
		6/11/96	0.0	14.5	360	---	---	---	---	---
		4/24/97	0.0	10.3	3,000	---	---	---	---	---
		6/22/98	1.3	9.2	320**	---	---	---	---	---
MPD	8	11/17/93	0.0	12.2	8,000	17,000	0.51U	0.51U	3.4	9.9
		8/8/95	0.0	13.9	8,400	23,000	25	38	70	96
		6/11/96	0.0	14.0	2,000	---	---	---	---	---
		4/24/97	0.0	10.3	8,400	---	---	---	---	---
		6/22/98	1.0	9.2	3600**	180	0.10	0.13	0.18M ^{i/}	0.16
MPE	4.5	4/24/97	3.5	7.2	840	280	0.062U	3.2	0.34	0.11
		6/22/98	12.1	7.2	30	---	---	---	---	---
MPE	7.5	4/24/97	1.0	8.5	460	---	---	---	---	---
		6/22/98	12.7	6.0	38	---	---	---	---	---
MPF	5	4/24/97	0.0	9.2	4,800	---	---	---	---	---
		6/22/98	1.1	7.0	560**	---	---	---	---	---

TABLE 1 (Continued)
SOIL GAS FIELD AND LABORATORY ANALYTICAL RESULTS
FORMER BUILDING 93, SITE SS-41
CHARLESTON AFB, SOUTH CAROLINA

Sample Location	Sample Depth (ft bgs) ^{b/}	Sampling Date	Field Screening Data			Laboratory Analytical Data ^{d/}				
			Oxygen (percent)	Carbon Dioxide (percent)	TVH (ppmv) ^{c/}	TVH (ppmv)	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Xylenes (ppmv)
MPF	7.8	4/24/97	0.0	10.2	>20,000	22,000	12	290	29	24M
		6/22/98	1.0	9.0	4200**	490	0.12	0.50	5.0M	9.0M
MPG	4.75	4/24/97	0.0	7.2	1,000	---	---	---	---	---
		6/22/98	6.0	4.2	20	---	---	---	---	---
MPG	7.75	4/24/97	0.5	9.5	2,200	560	0.11U	4.8	0.86	0.67
		6/22/98	1.2	2.8	32	1.4	0.0022U	0.0022U	0.012M	0.025M
MPH	4.25	4/24/97	0.0	4.9	560	---	---	---	---	---
		6/22/98	5.9	10.0	240	---	---	---	---	---
MPH	6.75	4/24/97	0.0	4.5	>20,000	3,800	0.54U	39	7.0	8.6M
		6/22/98	2.0	11.2	3,300	290	0.11U	0.11U	1.2	4.0M
MPI	5.5	4/24/97	1.0	11.8	1,900	20	0.13	0.13U	0.13U	0.13U
		6/22/98	1.2	22.5	>20,000**	140 ^{j/} 120	0.058/ 0.051	0.073/ 0.065	0.21/ 0.18	1.4M/ 1.2M
MPJ	5	4/24/97	0.0	10.2	3,200	1,800	<0.61	27	7.2M	5.8M
		6/22/98	4.7	15.0	3,600	1,900	0.35U	0.35U	12M	18M
MPK	5.3	4/24/97	0.2	7.0	>20,000	19,000	93M	14	34	100
		6/22/98	2.1	8.5	2800**	1,400	0.57U	0.57U	9.2	73M
MPL	4.8	4/24/97	0.8	5.5	380	---	---	---	---	---
		6/22/98	12.3	7.9	40	---	---	---	---	---
MPM	3.2	4/24/97	2.5	6.5	4,400	4,500	20	5.3M	5	28
		6/22/98	3.2	22.0	>20,000**	6,200	3.3	0.39U	24M	84M
MPN	5.5	4/24/97	4.5	4.2	400	---	---	---	---	---
		6/22/98	14.8	8.8	30	---	---	---	---	---
MW11	4.3-7.9	6/11/96	0.0	13.0	12,200	---	---	---	---	---
		6/22/98	1.4	11.0	1240**	---	---	---	---	---
MW12	4.3-12	6/11/96	7.8	8.0	1,600	---	---	---	---	---
		6/22/98	12.2	6.7	1000**	---	---	---	---	---

^{a/} Laboratory analysis of soil gas performed using USEPA Method TO-3, referenced to jet fuel (molecular weight = 156);

^{b/} ft bgs = feet below ground surface.

^{c/} TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume.

^{d/} NM = not measured due to presence of MP construction water in well screen.

^{e/} --- = not analyzed.

^{f/} ** denotes that the TVH meter reading includes methane.

^{g/} > = denotes field measurement greater than maximum meter reading.

^{h/} U = compound analyzed for, but not detected. Number shown represents the laboratory method detection limit.

^{i/} M = Laboratory reported value may be biased due to apparent matrix interferences.

^{j/} Primary/replicate sample results.

TABLE 2
RESPIRATION AND FUEL BIODEGRADATION RATES
FORMER BUILDING 93, SITE SS-41
CHARLESTON AFB, SOUTH CAROLINA

Sampling Location-Depth (feet bgs) ^{d/}	Pilot-Scale Test						Expanded-Scale Operation ^{b/}		
	Initial Results (Nov. 1993) ^{a/}		6-Month Results (Jan. 1995)		1-Year Results (Aug. 1995)		June 1998 Results		
	O ₂ Utilization (% O ₂ /hour)	Biodegradation Rate (mg/kg/year) ^{e/}	O ₂ Utilization (% O ₂ /hour)	Biodegradation Rate ^{c/} (mg/kg/year)	O ₂ Utilization (% O ₂ /hour)	Biodegradation Rate (mg/kg/year)	O ₂ Utilization (% O ₂ /hour)	Biodegradation Rate (mg/kg/year)	Biodegradation Rate (mg/kg/year)
VW1	0.32	450	0.033	50	0.078	130	---	---	---
VW2	0.40	630	0.016	25	0.084	140	---	---	---
MPA-5	---	---	0.017	31	0.056	110	---	---	---
MPA-8	0.42	700	0.038	70	0.14	280	0.17	330 ^{h/}	---
MPB-5	---	---	0.047	79	0.24	360	---	---	---
MPB-8	0.37	660	0.039	65	0.20	310	---	---	---
MPC-5	---	---	0.037	63	0.20	300	---	---	---
MPC-8	0.37	660	0.052	86	0.12	190	---	---	---
MPD-5	---	---	0.066	110	0.34	510	---	---	---
MPD-8	0.43	770	0.384	650	0.49	730	0.098	150 ^{h/}	---
MPF-7.8	---	---	---	---	---	---	0.43	650 ^{h/}	---
MPI-5.5	---	---	---	---	---	---	0.91	1400 ^{h/}	---
MPK-5.3	---	---	---	---	---	---	0.19	290 ^{h/}	---
MPM-3.2	---	---	---	---	---	---	0.64	970 ^{h/}	---

^{a/} Initial respiration data collected in November 1993; however, pilot testing did not begin until blower start-up on July 1, 1994.

^{b/} The expanded-scale bioventing system operated continuously from May 8, 1997 to May 21, 1998.

^{c/} Assumes moisture content of the soil is average of initial and 1-year analytical results.

^{d/} bgs = below ground surface.

^{e/} Milligrams of hydrocarbons per kilogram of soil per year.

^{f/} --- = Respiration test not conducted (MPF, MPI, MPK, and MPM were not installed until April 1997).

^{g/} Assumes moisture content of the soil is 13.5 percent.

^{h/} Assumes moisture content of the soil is 15 percent.

TABLE 3
GROUNDWATER ANALYTICAL RESULTS
FORMER BUILDING 93, SITE SS-41
CHARLESTON AFB, SOUTH CAROLINA

Analyte/ Concentration (µg/L) ^{a/}	Sample Location				
	MW-10	MW-11	MW-12	MW-14	VW 12
USEPA Method 8260B					
Benzene	0.4 U ^{b/}	0.4 U	0.4 U	0.4 U	0.4 U
Bromobenzene	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
Bromochloromethane	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
Bromoform	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Bromomethane	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
n-Butylbenzene	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
sec-Butylbenzene	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
t-Butylbenzene	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
Carbon tetrachloride	2.1 U	2.1 U	2.1 U	2.1 U	2.1 U
Chlorobenzene	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
Chloroethane	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Chloroform	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
1-Chlorohexane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Chloromethane	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
2-Chlorotoluene	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
4-Chlorotoluene	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U
1,2-Dibromo-3-chloropropane	2.6 U	2.6 U	2.6 U	2.6 U	2.6 U
Dibromochloromethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,2-Dibromoethane	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U
Dibromomethane	2.4 U	2.4 U	2.4 U	2.4 U	2.4 U
1,2-Dichlorobenzene	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
1,3-Dichlorobenzene	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
1,4-Dichlorobenzene	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
Dichlorodifluoromethane	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
1,1-Dichloroethane	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
1,2-Dichloroethane	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U
1,1-Dichloroethene	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
cis-1,2-Dichloroethene	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
trans-1,2-Dichloroethene	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U
1,2-Dichloropropane	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
1,3-Dichloropropane	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
2,2-Dichloropropane	3.5 U	3.5 U	3.5 U	3.5 U	3.5 U
1,1-Dichloropropene	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
cis-1,3-Dichloropropene	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
trans-1,3-Dichloropropene	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Ethylbenzene	0.6 U	0.6 U	0.6 U	0.6 U	0.6 U
Hexachlorobutadiene	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Isopropylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U

TABLE 3 (Continued)
GROUNDWATER ANALYTICAL RESULTS
FORMER BUILDING 93, SITE SS-41
CHARLESTON AFB, SOUTH CAROLINA

Analyte/ Concentration (µg/L) ^{a/}	Sample Location				
	MW-10	MW-11	MW-12	MW-14	VW 12
4-Isopropyltoluene	1.2 U	1.2 U	1.2 U	1.2 U	1.2 U
Methylene chloride	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
Naphthalene	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
n-Propylbenzene	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
Styrene	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
1,1,1,2-Tetrachloroethane	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
1,1,2,2-Tetrachloroethane	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
Tetrachloroethene	1.4 U	1.4 U	1.4 U	1.4 U	1.4 U
Toluene	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
1,2,3-Trichlorobenzene	0.3 U	0.3 U	0.3 U	0.3 U	0.3 U
1,2,4-Trichlorobenzene	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U
1,1,1-Trichloroethane	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U
1,1,2-Trichloroethane	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
Trichloroethene	1.0 U	1.0 U	1.0 U	1.0 U	1.0 U
1,2,3-Trichloropropane	3.2 U	3.2 U	3.2 U	3.2 U	3.2 U
1,2,4-Trimethylbenzene	1.3 U	1.3 U	1.3 U	1.3 U	1.3 U
1,3,5-Trimethylbenzene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Vinyl chloride	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
Bromodichloromethane	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U
o-Xylene	1.1 U	1.1 U	1.1 U	1.1 U	1.1 U
m,p-Xylene	0.5 U	0.5 U	0.5 U	0.5 U	0.5 U
Trichlorofluoromethane	0.8 U	0.8 U	0.8 U	0.8 U	0.8 U
USEPA Method SW8270C					
Naphthalene	10.2 U	10.2 U	10.2 U	10.4 U	10.2 U

Note: Groundwater samples were collected by Parsons ES on 6/23/98.

^{a/} µg/L = micrograms per liter.

^{b/} U = compound analyzed for , but not detected. Number shown represents the laboratory method detection limit.

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